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Integrating lean construction with BIM and sustainability: a comparative study of challenges, enablers, techniques, and benefits

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Abstract

Purpose – The construction industry has considerably evolved in the recent two decades due to the emergence of sustainability, lean construction (LC) and building information modelling (BIM). Despite previous research efforts, there is still a gap concerning the multidimensional nature of their integration. Hence, this study aims to fill the mentioned knowledge gap through exploring and comparing the challenges, enablers, techniques as well as benefits of integrating LC with BIM and sustainability in building construction projects.

Design/methodology/approach – A systematic literature review was conducted to fulfill the purpose of this study.

Findings – The findings reveal and compare the challenges, enablers, techniques and benefits of integrating LC with BIM and sustainability in building construction projects. The results suggest that there are eight common challenges for integrating LC with BIM and sustainability, including high initial cost, lack of collaboration, lack of professionals and lack of compatible contractual framework. The discovered challenges, enablers, techniques and benefits seem to be mostly routed in people. The findings also suggest that the synergistic benefits of integrating LC with BIM and sustainability can overcome the common challenges (safety, reliability, productivity, collaboration and quality) in construction projects.

Originality/value – The findings contribute to the literature and practice concerning the integration of LC with BIM and sustainability by exploring, comparing and discussing the relevant challenges, enablers, techniques as well as benefits. Moreover, the findings reveal the significance of the development of people in construction industry, besides processes and technology, as people are always subject of activities in construction while processes and technology are always objects.

Keywords Building information modelling (BIM), Lean construction, Sustainability

Paper type Research paper

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1. Introduction

The construction industry has faced several changes and developments in the recent two decades which represent significant improvements in the contractual relationships, project governance and project planning as well as control (Moradi *et al.*, 2020). In the holistic view, these improvements can be attributed to the advancements in the areas of people, processes and technology due to the emergence of lean construction (LC), sustainability and building information modelling (BIM) concepts and their representing tools and techniques (Avelar *et al.*, 2019; Koseoglu *et al.*, 2018; Koseoglu and Nurtan-Gunes, 2018; Mohammadi *et al.*, 2020; Marte Gómez *et al.*, 2021; Moradi *et al.*, 2021a; Orlov and Kankhva, 2022; Ramani and KSD, 2021; Wen, 2014). It can be said that this triangle of LC, sustainability and BIM represents a change of paradigm in construction industry from individuality and local optimization to team spirit, aligned interests and project optimization (Moradi *et al.*, 2021b).

LC can be defined as the effort for adopting and applying principles, tools and techniques of lean production in the context of construction. LC aims at understanding the value from the perspective of the customer and realizing the required product/service with the expected value and low waste (Mossman, 2018; Mao and Zhang, 2008; Salazar *et al.*, 2017; Sacks *et al.*, 2010). BIM can be defined as a set of technologies, processes and policies enabling multiple stakeholders to collaboratively design, construct and operate a facility in a virtual space (Bolpagni *et al.*, 2017a; Bolpagni *et al.*, 2017b; Eastman *et al.*, 2011; Fosse *et al.*, 2017; Herrera *et al.*, 2021). Sustainability in construction can be explained as the commitment and consistency in the responsible consumption of resources (both in terms of quality and quantity) in construction so that the current generation does not suffer from the negative consequence of the construction in their life and future generations inherit sufficient resources and clear as well as healthy environment as the current generation did (Bajjou *et al.*, 2017; Moradi and Kähkönen, 2022a, 2022b).

The research community has been very active in studying LC, sustainability and BIM to explore their advantages and disadvantages both individually and in connection to each other (Banawi and Bilec, 2014; Schimanski *et al.*, 2019; Wijerathne *et al.*, 2019). According to the previous studies, LC, sustainability and BIM concepts and practices provide great advantages for construction projects when used individually, but greater benefits if used together. This refers to their potential synergistic effects which can be considerably useful if they were used together to realize their collective benefits and to cover their shortages. In this regard, there have been a few studies focusing on the combination/integration of LC and BIM, and LC and sustainability, separately. However, a comprehensive analysis of different aspects of combining and integrating LC with BIM and sustainability has been addressed in a very limited manner. Therefore, this study aims to fill the mentioned knowledge gap through answering the following questions:

RQ1. What are the challenges, enablers, tools and techniques and benefits for integrating LC with BIM and sustainability?

RQ2. What are the commonalties among those challenges, enablers, tools and techniques and benefits?

RQ3. What is the message behind the intensity, existence or lack of commonality among those challenges, enablers, tools and techniques and benefits?

The resulting article is structured in six sections. The Section 2 presents the theoretical background. Then, the methodology is explained in Section 3, which is followed by presenting and discussing the results and findings in Sections 4 and 5, respectively. Finally, the conclusions, drawn from the findings, are stated in Section 6.

2. Theoretical background

2.1 Lean construction

Although lean processes and activities in construction are relatively new (the Lean Construction Institute – LCI goes back to the early 1990s), but the ideas of Lean can be traced to the Shewhart's 1930s QA/QC Plan–Do–Check–Act cycle (Koskela *et al.*, 2019). The emergence of LC through the adoption of lean production principles, tools and techniques was a response and reaction to the limited collaboration between people and low reliability of planning and production processes in construction projects (Forbes and Ahmed, 2010; Oakland and Marosszeky, 2017). The origin of these problems in construction projects seems to be factors such as the lack of trust among project participants, unfair share of risk-reward, focus on the low-price criteria for selecting the contractor, low reliability of the plans and lack of early involvement of contractor and its team in project definition and design phases (Moradi *et al.*, 2021b; Oakland and Marosszeky, 2017). In terms of the theoretical origin, LC is based on Transformation-Flow-Value theory which was propositioned by Lauri Koskela (Koskela, 1992). Transformation is defined as the production of inputs into outputs. Flow is explained as the movement that is smooth and uninterrupted, as in the flow of work from one crew to the next. And value is what the client is actually willing to pay for the project deliverables (Cheng, 2015). A detailed history of the emergence of LC can be found in the article published by Ballard and Howell (2003). Furthermore, the proceedings of annual conferences of the International Group for Lean Construction (IGLC) provide additional information concerning the previous studies on this topic.

A consequence of emerging LC was the development of lean project delivery system by Ballard (2000). In lean project delivery system, project life cycle is divided into project definition, lean design, lean supply, lean assembly and use (Ballard and Howell, 2003). Lean project delivery addresses construction as production. Therefore, production planning and control is a critical part of lean project delivery system which is handled through last planner system (Ballard and Howell, 2003). According to Ballard (2020), last planner system limits project master schedule to the milestone level of the detail and involves those project participants (construction team), which are directly responsible for doing the work. Last planner system is consisted of five components which are master scheduling (only key milestones), phase scheduling (3–6-month horizon), look ahead planning (4–8-week horizon), daily/weekly work planning and learning. More information about collaborative delivery models (including lean project delivery system) in construction projects can be found in the article published by Moradi *et al.* (2022).

2.2 Building information modelling

BIM can be defined as a method to visualize the project and its spaces, structures, components and materials with their essential information and properties (Fosse *et al.*, 2017). BIM can be also understood as a set of technologies, processes and policies enabling multiple stakeholders to collaboratively design, construct and operate a facility in virtual space (Bolpagni *et al.*, 2017a).

According to Herrera *et al.* (2021), the application of BIM for design and planning of construction projects contains cost estimation, 4D planning, site analysis, space programming, design review, sustainability evaluation, engineering analysis and 3D coordination. In terms of lean and BIM interplay, it can be said that BIM contributes towards trustworthiness of information, and LC enriches and enhances the reliability of processes. Although LC and BIM are not dependent on each other, their integration in practice can provide great benefits and advantages compared to their individual application (Sacks *et al.*, 2010).

2.3 Sustainability

Sustainability in construction, according to Laconte and Gossop (2016), can be observed in three levels of individual buildings, neighborhood and urban level sustainability. Sustainability of individual buildings, as the foundation, subsequently affects neighborhood and urban level sustainability. Recognizing destructive impacts of construction projects on society, economy and environment led to the emergence of sustainability in the context of construction in 1990s, as the subset of sustainable development goals, outlined by UN (Moradi and Kähkönen, 2022a, 2022b). Several scholars have defined sustainability in construction and summary of those definitions is that sustainable construction refers to all efforts which are required for realizing needs of current generations in terms of built environment while avoiding sacrifice of future generations' right for inheriting sufficient raw materials, clean and healthy environment and economy and society (Bajjou *et al.*, 2017; Tafazzoli *et al.*, 2020; Wijerathne *et al.*, 2019). Sustainability in construction has three attributes which are environment, society and economy. According to Moradi and Kähkönen (2022a, 2022b), environmental sustainability involves adoption to climate changes, energy efficiency in construction and operation, minimizing pollutions, protection of the environment (natural heritage) and waste minimization as well as elimination throughout the project life cycle. The same resource stated that social sustainability refers to supporting local economy and people, well-being of project practitioners and local residents during and after project, resilient planning for future expansions and hazards, active engagement of all project stakeholder and preserving the cultural heritage. They also mentioned that economic sustainability in construction addresses cost management with life cycle perspective (project and product), stakeholder satisfaction for reoccurring business, continuous improvement on productivity through less rework and defects, value creation and delivery for client and project management.

Alike LC and BIM, LC and sustainability, as can be understood, have synergistic effects which can be realized if they integrated and used together. The previous studies addressing integration of LC and BIM, and LC and sustainability are explained in the following in a concise manner.

2.4 Previous research

Regarding LC and sustainability, exploring their synergistic effects by addressing their interfaces is one of major aspects which have been studied by different scholars (Ahuja, 2013; Benachio *et al.*, 2021; Cunha and Lima, 2017; Daniel and Pasquire, 2019; Watkins and Sunjka, 2020). Another major aspect has been discovering enablers, challenge and benefits for realizing lean and sustainable construction (Aslam *et al.*, 2021; Bajjou *et al.*, 2017; Jagannathan *et al.*, 2018; Pandithawatta *et al.*, 2019; Wijerathne *et al.*, 2019).

Regarding LC and BIM, the mentioned patterns for LC and sustainability, can be also recognized here, meaning that LC and BIM, as research topic, has been studied from different aspects which include barriers, enablers and benefits of joint application (Bolpagni *et al.*, 2017a; Evans and Farrell, 2020; Fosse *et al.*, 2017; Evans *et al.*, 2020; Gong *et al.*, 2017; Koseoglu *et al.*, 2018; Von Heyl and Demir, 2019; Marte Gómez *et al.*, 2021), interfaces and synergies (Herrera *et al.*, 2021; Nascimento *et al.*, 2017; Nascimento *et al.*, 2018; Sepasgozar *et al.*, 2021) and integration (Evans *et al.*, 2021; Moghadam *et al.*, 2012; Maraqa *et al.*, 2021; Sarhan *et al.*, 2019; Wen, 2014).

The addressed topic in the areas of LC-BIM and LC-Sustainability shows that research community has actively addressed different aspects of applying them together and benefiting from their collective advantages. However, these is an issue regarding the previous studies. The issue is that majority of the mentioned studies have looked into the integration challenge and/ benefits either in the context of LC and BIM or LC and sustainability. And a comprehensive analysis of different aspects of combining and integrating LC, sustainability and BIM, altogether, has been addressed in a very limited manner. Consequently, there is currently very limited research-based knowledge concerning the commonalities and specificities regarding the challenges, enablers, tools and techniques as well as benefits of integrating LC, BIM and sustainability in construction projects. Hence, this study aims to the fill the mentioned knowledge gaps through the answering the research questions which were mentioned in the Introduction section.

3. Methodology

3.1 Research design

This study used systematic literature review for answering the mentioned research questions in the Introduction section. Therefore, locating the relevant studies from Scopus database was followed by excluding irrelevant ones and repetitions through abstract and full-text review. The process of data collection and analysis in this research is illustrated in Figure 1 and explained in detail in the following sub-sections.

3.2 Keyword selection

This study used Scopus database for identifying the relevant studies. The reason for choosing Scopus database was its inclusiveness in terms of covering almost all the relevant journals in the field of construction and project management. Choosing "Lean Construction" as the only keyword was justified through this study's focus which was on the previous research addressing LC with BIM and/or sustainability. This justification for using "lean construction" as the keyword was considered sufficient for locating those studies focused on LC and BIM or LC and sustainability.

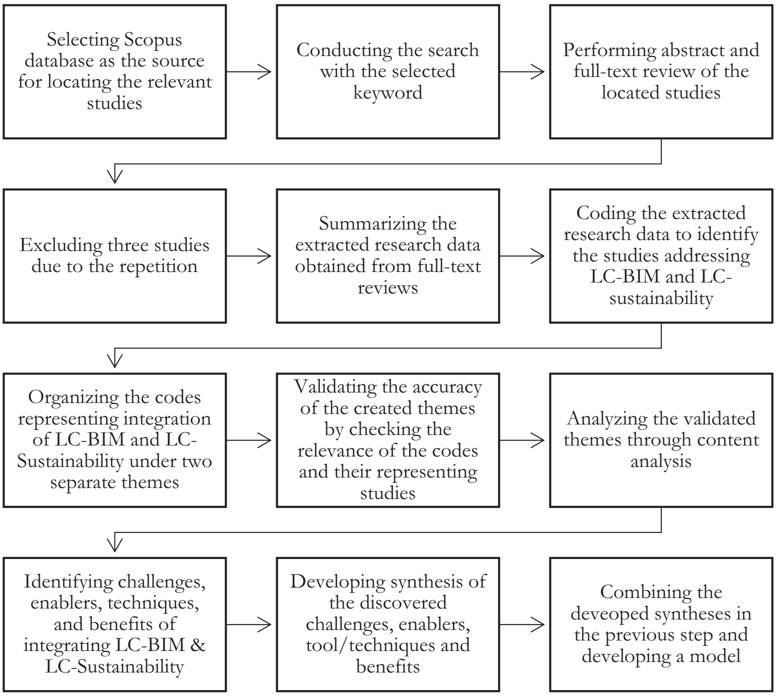

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Figure 1.
Research process

3.3 Descriptive statistics

The performed search resulted in locating 230 accessible studies by the authors. In total, 3 out of those 230 located studies were excluded because of the repetition. This was followed by reviewing and analysing full text of the remaining 227 studies. Table 1 shows the type and number of the located studies. Searching for relevant studies contained no specific time span to increases the comprehensiveness of the search. In terms of the publication period, more than 85% of the 227 analysed studies were between 2011 and 2022.

3.4 Conceptualization: thematic analysis and model development

After locating the relevant studies, they were analysed through thematic analysis (Saunders *et al.*, 2019). This was undertaken by inductively coding the extracted research data. The labels of the codes were data derived by the researcher. According to the purpose of this study, the codes representing LC-Sustainability and LC-BIM were structured under a theme entitled "LC-BIM-Sustainability." Then, the codes under the developed theme were further analysed through content analysis in three steps: first, the challenges, enablers, tools and techniques and benefits of integrating LC and sustainability, and LC and BIM were identified and synthesized separately. Then, in the second step, the commonalities among the challenges, enablers, tools and techniques and benefits of integrating LC and sustainability, and LC and BIM were explored based on the similarity or sameness in their meaning and/or title. Finally, in the third step, those common challenges, enablers, tools and techniques and benefits were formed a model for the integration of LC with BIM and sustainability.

4. Results

4.1 Integrating lean construction with building information modelling and sustainability

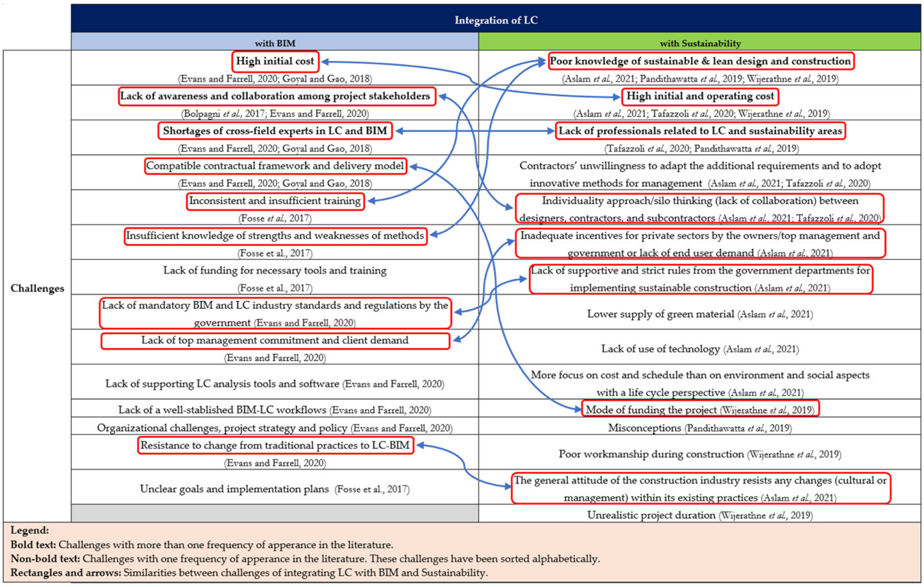
The first group of findings present the challenges, enablers, tools and techniques and benefits of integrating LC with BIM and Sustainability. This group of findings also answer the mentioned research questions in the Introduction section.

4.1.1 Challenges. The first group of findings present challenges of integrating *LC with BIM and sustainability*. As can be seen in Figure 2, there are three frequently mentioned challenges (in bold font) of which high initial cost and lack of competent people are the common ones. This means that solutions (either related to technology or processes) need to be economical and financially feasible and require sufficient investment for competence development. A possible reason that high initial cost has become a serious challenge could be lack of long-term cost and benefit analysis for clarifying the benefits which client/owner could get in mid and long term by tolerating that high initial cost.

Lack of relevant contract and delivery model supporting collaboration among individuals and companies in projects are also common challenges for integrating LC with BIM and sustainability. In other words, the findings show that traditional delivery models (design-bid-build, design-build), due to their characteristics and elements, are not strong supporters of integrating LC with BIM and sustainability. Another important and common

Type of the analysed studies	No.
Journal articles	124
Conference proceedings	103
Out of scope (repetitions)	3
Total	230

Table 1. Type of the analysed studies



	Integration of LC	
	with BIM	with Sustainability
Challenges	**High initial cost** (Evans and Farrell, 2020; Goyal and Gao, 2018)	**Poor knowledge of sustainable & lean design and construction** (Aslam *et al.*, 2021; Pandithawatta *et al.*, 2019; Wijerathne *et al.*, 2019)
	Lack of awareness and collaboration among project stakeholders (Bolpagni *et al.*, 2017; Evans and Farrell, 2020)	**High initial and operating cost** (Aslam *et al.*, 2021; Tafazzoli *et al.*, 2020; Wijerathne *et al.*, 2019)
	Shortages of cross-field experts in LC and BIM (Evans and Farrell, 2020; Goyal and Gao, 2018)	**Lack of professionals related to LC and sustainability areas** (Tafazzoli *et al.*, 2020; Pandithawatta *et al.*, 2019)
	Compatible contractual framework and delivery model (Evans and Farrell, 2020; Goyal and Gao, 2018)	Contractors' unwillingness to adapt the additional requirements and to adopt innovative methods for management (Aslam *et al.*, 2021; Tafazzoli *et al.*, 2020)
	Inconsistent and insufficient training (Fosse *et al.*, 2017)	Individuality approach/silo thinking (lack of collaboration) between designers, contractors, and subcontractors (Aslam *et al.*, 2021; Tafazzoli *et al.*, 2020)
	Insufficient knowledge of strengths and weaknesses of methods (Fosse et al., 2017)	Inadequate incentives for private sectors by the owners/top management and government or lack of end user demand (Aslam *et al.*, 2021)
	Lack of funding for necessary tools and training (Fosse et al., 2017)	Lack of supportive and strict rules from the government departments for implementing sustainable construction (Aslam *et al.*, 2021)
	Lack of mandatory BIM and LC industry standards and regulations by the government (Evans and Farrell, 2020)	Lower supply of green material (Aslam *et al.*, 2021)
	Lack of top management commitment and client demand (Evans and Farrell, 2020)	Lack of use of technology (Aslam *et al.*, 2021)
	Lack of supporting LC analysis tools and software (Evans and Farrell, 2020)	More focus on cost and schedule than on environment and social aspects with a life cycle perspective (Aslam *et al.*, 2021)
	Lack of a well-stablished BIM-LC workflows (Evans and Farrell, 2020)	Mode of funding the project (Wijerathne *et al.*, 2019)
	Organizational challenges, project strategy and policy (Evans and Farrell, 2020)	Misconceptions (Pandithawatta *et al.*, 2019)
	Resistance to change from traditional practices to LC-BIM (Evans and Farrell, 2020)	Poor workmanship during construction (Wijerathne *et al.*, 2019)
	Unclear goals and implementation plans (Fosse et al., 2017)	The general attitude of the construction industry resists any changes (cultural or management) within its existing practices (Aslam *et al.*, 2021)
		Unrealistic project duration (Wijerathne *et al.*, 2019)

Legend:
Bold text: Challenges with more than one frequency of apperance in the literature.
Non-bold text: Challenges with one frequency of apperance in the literature. These challenges have been sorted alphabetically.
Rectangles and arrows: Similarities between challenges of integrating LC with BIM and Sustainability.

Figure 2.
Challenges of integrating LC with BIM and sustainability

Source: Authors' own work

challenge, here, is the lack of relevant, supportive and mandatory standards, codes and regulations. Furthermore, lack of top management support together with client demand and resistance to change are also seen among the common challenges for integrating LC with BIM and sustainability.

The high number and types of commonalities between challenges for integrating LC with BIM and sustainability highlight the significance of people (equipped with required knowledge, skill, awareness and willingness to collaboration), processes (fostering collaboration from the beginning of the project) and governance (providing contractual and organizational equality to build trust and communicate openly).

4.1.2 Enablers. Enablers of integrating LC with BIM and sustainability clearly reflect on the challenges which were discussed earlier. As can be seen is Figure 3, collaboration among project participants, collaborative project delivery model, government policy support and owner/client's commitment, support and demand seem to be the common and critical enablers for integrating LC with BIM and sustainability. The specific enablers, however, are mainly related to the technical aspects of BIM and sustainability.

4.1.3 Tools and techniques. Figure 4 shows a list of the required tools and techniques for integrating LC with BIM and sustainability. As can be seen, value stream mapping, last planner system and target value design have been detected as the commonalities here. Among these identified commonalities, last planner system and target value design, again, reflect on the challenges which were discussed earlier and imply the essence of continuous and constructive collaboration between project participants and parties throughout project life cycle, particularly in the project definition and design and planning phases.

An obvious difference here compared to the discussed enablers and challenges, is the low number of the commonalities between tools and techniques for integrating LC with BIM and sustainability which could be explained through the contingency theory; one size does not fit

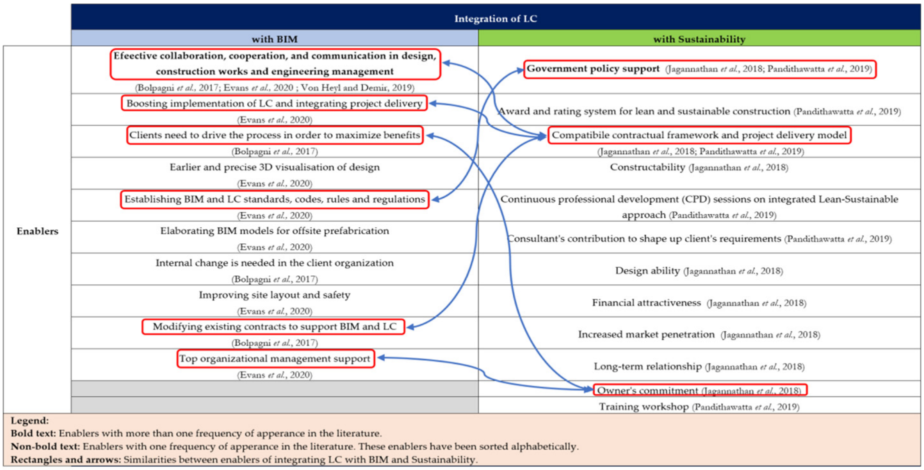


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Figure 3. Enablers of integrating LC with BIM and sustainability

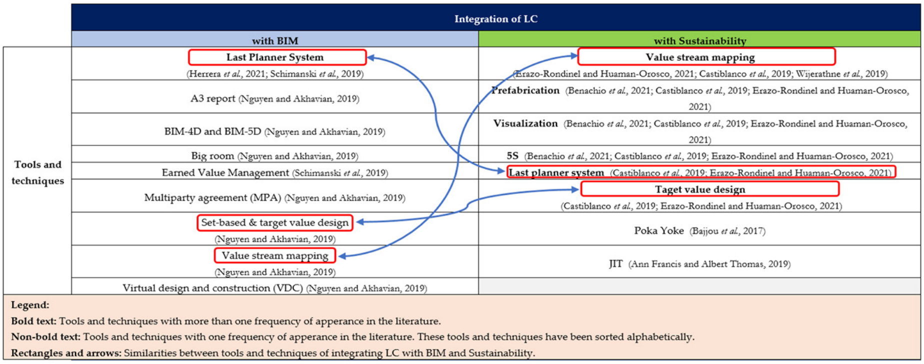

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Figure 4. Required tools and techniques for integrating LC with BIM and sustainability

all. This means that besides those tools and techniques which foster and support collaborative working, field-specific tools and techniques are also required.

4.1.4 Benefits. The last, but not least, group here to discuss is the benefits of integrating LC with BIM and sustainability. The first impression here is that the benefits of integrating LC with BIM has been addressed more than the benefits of integrating LC with sustainability. This could explain also the difference in the number of identified benefits in each group. Secondly, it is interesting to see that there is considerable overlap between the benefits of integrating LC with BIM and sustainability, despite of the difference in the number of benefits in each group. As can be seen, integrating LC with BIM and sustainability has several benefits of which increased efficiency, waste reduction and minimization, cost reduction, quality improvement and customer satisfaction are the common ones in both groups. But if LC, BIM and sustainability were used together, all of the listed benefits in Figure 5 could be realized as their synergistic effect on project success.

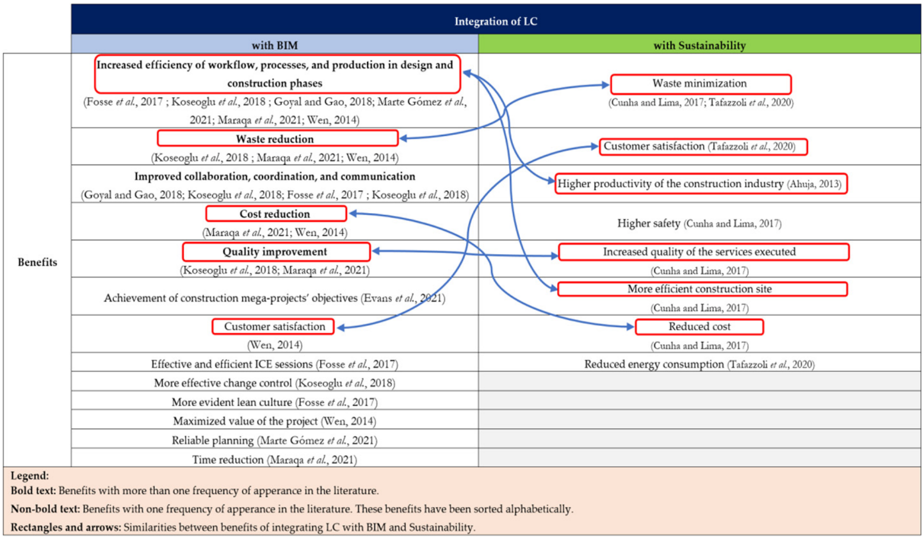

Figure 5. Benefits of integrating LC with BIM and sustainability

Source: Authors' own work

Another interpretation here, which could be somewhat controversial, is that integrating LC with BIM alone, significantly contributes towards achievement of most of the sustainability goals and benefits as well, but not all of them. However, the collective benefits of integrating LC with BIM and sustainability, altogether, still seem to be greater than their separate application and can overcome the common and long-term challenges of construction projects which are known to be accident-free construction, reliable planning and production, quality work through doing it right at the first time, collaboration between project parties and high efficiency in terms of cost, time and low waste.

4.2 Common challenges, enablers, tools and techniques and benefits of integrating lean construction with Building information modelling and sustainability

The developed model in Figure 6 sums up the findings and portrays commonalities between challenges, enablers, tools and techniques and benefits of integrating LC with BIM and sustainability.

5. Discussion

This study explored the challenges, enablers, tools and techniques as well as benefits of integrating LC with BIM and sustainability. Moreover, the commonalities between those challenges, enablers, tools and techniques as well as benefits were identified and presented.

Regarding the challenges, it looks obvious that majority of the critical challenges for integrating LC with BIM and sustainability are rooted in people, either directly or indirectly. This relevance can be understood as the lack of required competence, knowledge, commitment and awareness towards integration of LC, BIM and sustainability. The same effect also applies to each of the mentioned concepts individually, as mentioned in the previous studies (Aslam *et al.*, 2021; Evans and Farrell, 2020; Fosse *et al.*, 2017). It seems that construction industry has not focused enough on development of people as much as it has paid attention to the development of technology and processes. There is no doubt that

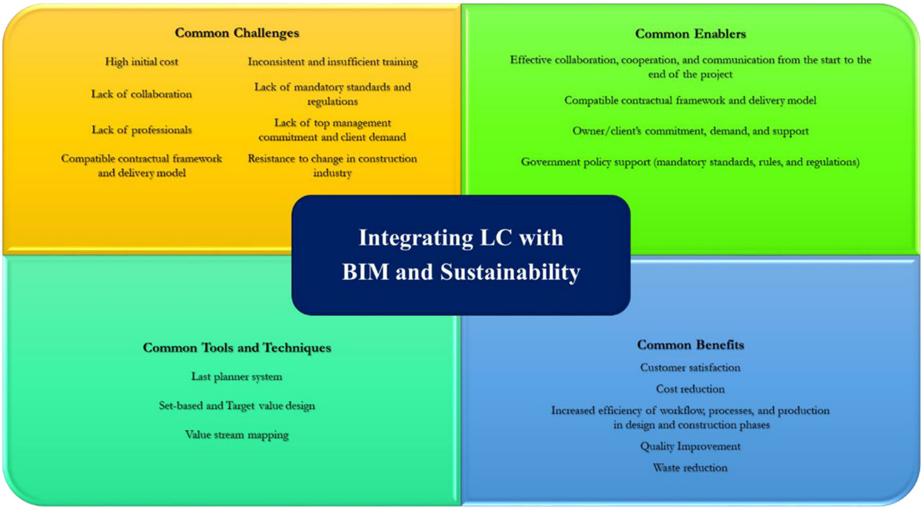

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Figure 6. Common challenges, enablers, tools and techniques and benefits of integrating LC with BIM and sustainability

up-to-date technology and processes are vital for achieving lean and sustainable construction, but it is also important to note that technology and processes are eventually used by people and if competent and committed human resource (by all means) is missing, then it is challenging to expect successful outcome as it has been identified in this study and previous ones (Laconte and Gossop, 2016).

Regarding enablers, it is interesting to see the reflection of the discovered challenges on the explored enablers. Compatible contractual framework, collaboration throughout project and support policies by government are the key enablers, identified in this study, which greatly match with the mentioned challenges as they both are related to people in project and in society. Other examples of the human-related enablers for integrating LC with BIM and sustainability are cultural transformation, top management support, owner's commitment, long-term relationship and exchange of information (Figure 3). The great role of people, as a key element in LC-BIM-Sustainability integration, can be also recognized in the identified tools and techniques, but, in combination with technology and processes aspects. If we look carefully at the highlighted tools and techniques in Figure 4, last planner system, target value design, value stream mapping, virtual design and construction represent an integration of people, processes and technology. Thus, it can be argued that equal attention to people, process and technology is a key strategy for achieving integration of LC, BIM and sustainability and realizing their collective benefits which seems to be colossal, as they are explained in the following.

Finally, it is really interesting to see that even the identified benefits of integrating LC with BIM and sustainability are highly related to people. For instance, waste minimization, efficient workflow, increased efficiency, improved coordination and collaboration and quality improvement are also results of actions which are human-centered. In other words, people are always subjects of activities in construction while processes and technology are the objects, and there seems to be a clear and logical relationship between efforts for developing people and benefits/loss in the project. This means that the more we invest on people as the subject of project activities, the more we will gain in terms of efficiency of processes and technology, which will finally result in project success.

This study's findings considerably contribute towards the body of knowledge on integrating LC with BIM and sustainability. The obtained results not only provide practical insights for project practitioners in terms of challenges, enablers, techniques and benefits of integrating LC with BIM and sustainability but also enrich theory through portraying the significant and somewhat overlooked role of people and their development in the efficiency of process and technology in construction projects. The findings will also be a frame of reference for the future relevant studies.

6. Conclusions

This study aimed to address integration of LC with BIM and sustainability in construction projects. This was realized through undertaking a systematic literature study and exploring relevant challenges, enablers, techniques and the benefits. The obtained results provided a basis for the following conclusions:

- Challenges, enablers, tools and techniques, and benefits of integrating LC, BIM and sustainability seem to be mostly rooted in people.
- People are always subjects of activities in construction while processes and technology are the objects. Therefore, the more we invest on people as the subject of project activities, we will gain more in terms of efficiency of processes and technology, which will finally result in project success.
- LC is about collaborative people and reliable processes. Last planner enables this collaboration and reliability, and BIM facilitates it. A resultant outcome seems to be sustainable practices.
- Synergistic benefits of integrating LC with BIM and sustainability can overcome the common challenges in construction projects which are known to be accident-free construction, reliability of planning and production, quality work by doing it right at the first time, collaboration between project parties and high efficiency in terms of cost, time and low waste.
- There are eight common challenges for integrating LC with BIM and Sustainability, including high initial cost, lack of collaboration, lack of professionals and lack of compatible contractual framework and delivery model.
- There are four common enablers for integrating LC with BIM and Sustainability which include continuous and constructive collaboration, compatible contractual framework and delivery model, owner/client's demand, support and commitment.
- There are three common tools and techniques integrating LC with BIM and sustainability, which include last planner system, set-based and target value design and value stream mapping.
- There are five common benefits of integrating LC with BIM and sustainability, which include customer satisfaction, cost reduction, increased efficiency, quality improvement and waste reduction as well as elimination.

This study's findings contribute towards the body of knowledge on LC and sustainability and their integration. The results are also insightful for project practitioners from the practical perspective. As the limitations of this study, it is acknowledged that application of a certain keyword in Scopus database for conducting the search might have affected reliability and generalizability of this study's findings. The obtained results also raised the following questions which can be the departure point for the future studies:

- Do the complexity and type of building construction project diversify the challenges, enablers, tools and techniques and benefits of integrating LC, BIM and sustainability?
- What kind of mandatory standards, rules and regulations can facilitate the integration of LC, BIM and sustainability in building construction projects?
- What are the characteristics of a compatible contractual framework through which LC, BIM and sustainability can be applied together in different types of building construction projects?
- What are the required competencies for managing the integration of LC, BIM and sustainability in building construction projects?

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